Some practical comments on the draft compiled SAB EPEC ballast water document

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Two comments from Nick Welschmeyer, Subgroup 1 member.

1) **Add comment from group 1**. Page 35, line 42 of the overall draft document to the list of draft conclusions:

"The performance of the five BWMS types (*that passed IMO Type Approval*) is duly impressive since the organism disinfection or removal efficiency is often reduced by four orders of magnitude, which exceeds that typically required for the performance of drinking water treatments".

I am surprised at how *often* our document acknowledges the notion of 'more stringent' standards and how *rarely* it acknowledges the remarkable efficacy of successful current treatment technologies. A central theme seems to be evolving (rightfully): notions of 10-fold, 100-fold and 1000-fold increases in stringency are <u>fading</u> in the reality of statistics and practical measurement logistics. This is a strong statement that needs to be made in our document, <u>not by innuendo</u>, but by statement of facts: a 10,000-fold reduction in large living organism concentration (>50 um) is a hallmark of environmental success!!

2) **Issue of live counts**: I've attached a simple PowerPoint on the topic of numeric live counts (especially of large plankton). I have read the eloquent statistical discussions provided *before* the SAB final meeting and *in summary* for the SAB final meeting. Lee et al is 64 pages; Miller et al is 23 pages; Conquest et al (I believe Loveday provided that nice section) is 27 pages (that's a lot of total page space).

   These are beautiful documents that I thoroughly enjoyed reading and, in my mind, they point to one blatantly obvious fact: the state of affairs in ballast large organism (>50 um) live counts is, in a word… miserable! We must shout this out loud. The treatment counts are too low, the required volumes are too large and the mortality impacts from massive concentration processes (sieve concentration) collectively yield an analytical measurement of dubious honor. In fact, it points to the ACTUAL success of ballast treatment… we have reduced the large organism numbers to such a low level, we can't count 'em - and we can barely put a statistical error limit on our results! No analytical scientist wants to live in the open territory of the Poisson distribution if they have a choice for more robust approaches; give me the normal distribution any day.

Suggestion: Develop methods for, and count microbes; develop proxies for living biomass. Please see the Powerpoint suggestions.

(a much-needed statement of the problem)

Ballast Regulations/Ballast Treatment Testing:

The *Big* Dilemma:

- Individual 'living' organisms are the propagules of biological invasion
- Therefore, numeric counts of 'living' organisms are the logical unit of measurement for ballast water regulations

Unfortunately, numeric 'live' counts are:

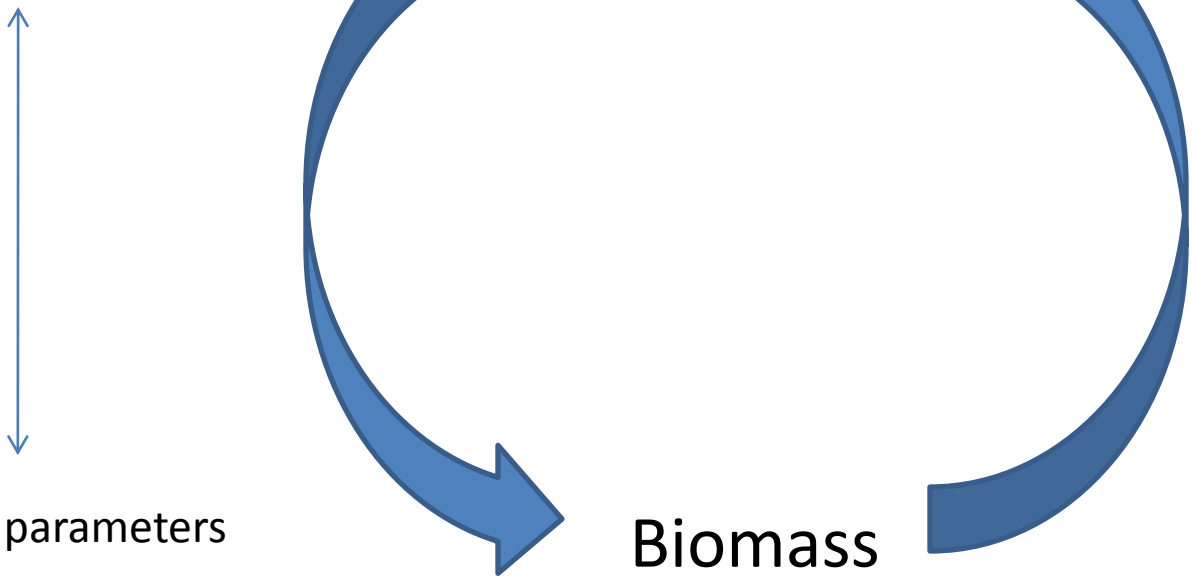
- Tedious (microscopy)
- Subjective (human error)
- Statistically-challenged (low counts)
- Logistically-challenged (organism die-off; huge volume requirements)
- Impossible (or untested) for some plankton size classes (unicells)

Measurements of planktonic biota usually represent compromise:

Species (individuals) vs. Biomass

(numeric counts, species names, nucleotide sequences, etc.)

Specificity

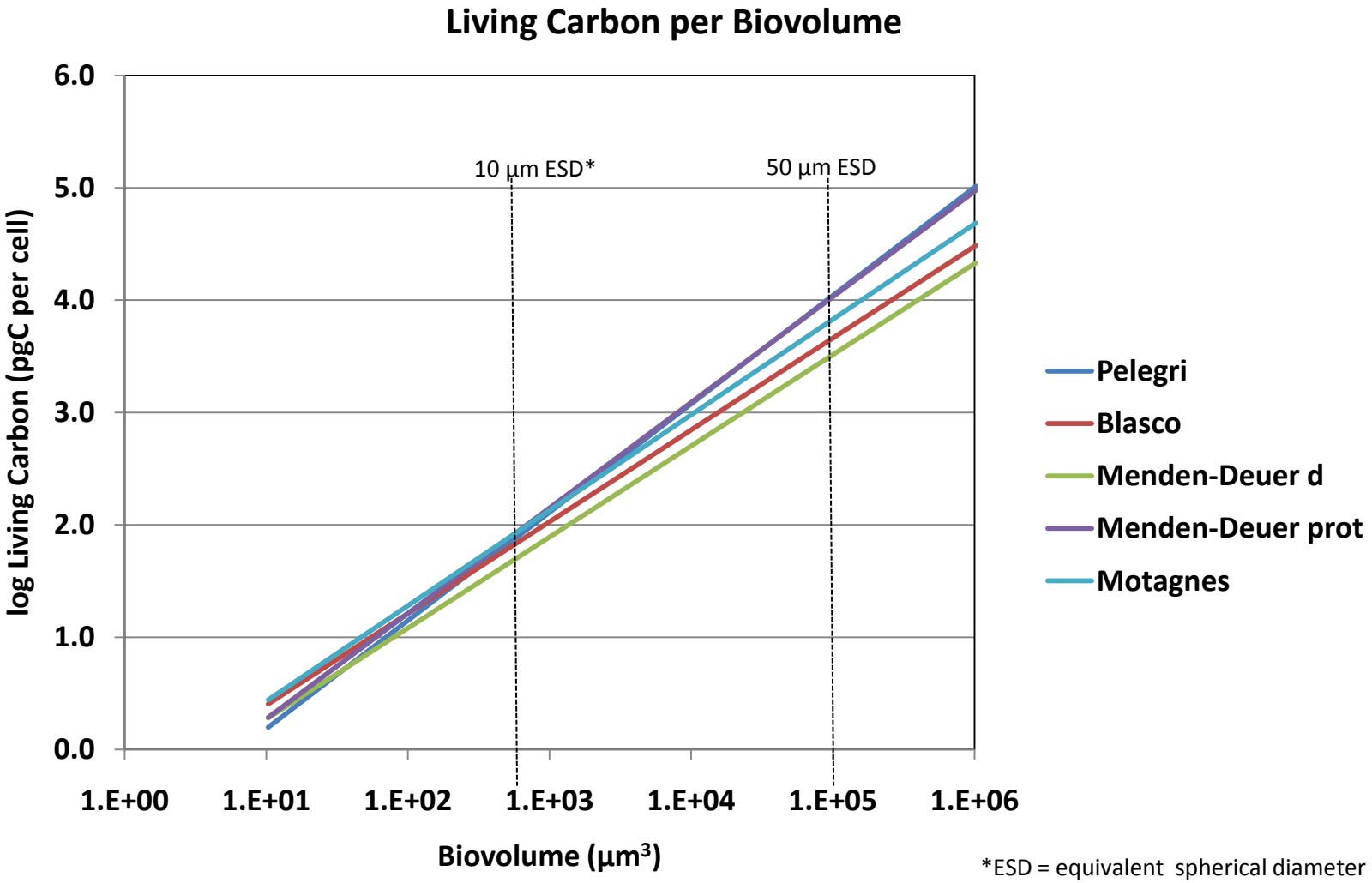


Bulk parameters

(Chlorophyll a, ATP, organic carbon, etc.)

The bulk mass of 'living' carbon can be (and has been) computed from estimates of organism size (biovolume). [supported by at least 11 careful, empirical studies (journal publications) made over the last 40 years]. Thus, a size-defined, regulatory numeric concentration limit (e.g., counts of 10 – 50 µm organisms) can be converted to its equivalent 'living' carbon concentration.

Example: log Carbon (pgC/cell) = 0.94 * log vol (µm^3) – 0.6 (Strathman 1967)



*ESD = equivalent spherical diameter

Potential solutions to the 'numeric count' problem in ballast regulation/testing:

1. Ignore 'large' organisms – they are too rare!!!
2. Focus on smaller organisms, they are more numerous by orders of magnitude (this will remedy the logistical problems of *large volumes* and *unacceptable statistics*)
3. A. Count living micro organisms in the bacteria size class (they are the most numerous). (unfortunately, counting is tedious and therefore, NOT desirable).
   B. Better. Use techniques (or develop techniques) that provide estimates of living carbon. Develop minimum detection levels, establish blanks, engineer simple assays that require minimum volume requirements and simple manipulations.
   Consider 'non-detectable' to be the equivalent of zero (best available technology)
4. Simplify. Pick an acceptable regulatory 'living carbon equivalent' for a suitably small organism size class (smart logistics) and develop a positive/negative pregnancy-style test;
   Yes or no… does the sample exceed the limit?
5. Use physiological tests based on optics, e.g., PAM fluorescence. Exploit one organism group (phytoplankton) that displays optical characteristics of physiological competence as a proxy for treatment effects on ALL organism groups. (This approach ignores numeric concentrations and it ignores biomass concentrations, but… it paves the way for real-time physiological indications of treatment success - at the test facility, at the dock, and while under operation at sea).

Current Ballast Treatment Efficacy can be very high (IMO is pretty darn good relative to drinking water):

- IMO/USCG P1 land-based 'challenge' concentration – 100,000 organisms/m^3
- IMO/USCG P1 regulatory limit – 10 organisms/m^3

Table 2.

Organism	Water Source	Disinfection (%)	Log Reduction	Reference
Cryptosporidium	Drinking Water	99	2 log	EPA Surface Water Treatment Rule (1990)
Giardia lamblia	Drinking Water	99.9	3 log	EPA Surface Water Treatment Rule (1990)
Zooplankton (>50µm)	Ships Ballast Water	99.99	4 log*	IMO G8 D2 Guidelines (2004)

*IMO D-2 and USCG Phase-1 standards (<10 living organisms m^{-3}) represents a 4-log reduction relative to the required minimum challenge water concentration of 100,000 living organisms m^{-3}.